Suitability of an Evapotranspiration Waste Disposal System for Selected Semi-primitive Mountain Environments During the Winter

by

Victor R. Hasfurther

Final Report

Cooperative Agreement No. 16-460-CA
(EC-124)

Rocky Mountain Forest and Range
Experiment Station
Ft. Collins, Colorado

CIVIL AND ARCHITECTURAL ENGINEERING

University of Wyoming, Laramie

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INTRODUCTION

The increasing demand for mountain recreation and second home developments creates problems within many segments of our society. Part of the attraction of mountain areas are the unpolluted lakes and streams present in many of these areas. In addition, clean, cold mountain surface and ground waters are increasingly being used for water supplies at second home sites. Yet as development of recreational areas increase, the preservation and improvement of the environment has become a concern to a wide variety of interests such as planners, environmentalists, socioeconomists and industrial and commercial interests. Even with this concern, however, many second home developments provide inadequate or no means of handling human wastes generated at these sites. The end result may be a drastic deterioration in the natural beauty and recreational opportunities which attract people to these sites in the first place. Goldstein (1973) estimated that in the United States some 30 percent of the population depends on septic tank and cesspool installations, outmoded privies or direct discharge to water courses for treatment of wastes. The use of these types of treatment facilities is the result of technology not paying attention to adequate treatment of wastes of single family dwellings such as second homes in semi-primitive mountain areas and other remote areas compared to central treatment systems developed for large communities. It is thus of paramount importance that better means of treating wastes from single family dwellings be developed at a reasonable cost to the consumer which will not pollute surface or ground waters.

The liquid wastes which seep from septic tanks and privies and the direct discharges which occur to streams is highly polluted and can under certain circumstances contaminate a significant portion of the surrounding ground and surface water systems of what previously were unpolluted natural mountain recreational environments. One possible alternative to these presently used systems for wastewater treatment for single second home dwellings in semi-primitive areas is the use of evapotranspiration waste disposal systems. The evapotranspiration waste disposal system uses a confining unit which seals the wastewaters from the surrounding soil by a reinforced rubber membrane which results in no surface or subsurface outflow and thus the only means of removal of the wastes and water is by evapotranspiration from the soil and plants within the unit and by gases escaping into the atmosphere. The end result is elimination of the possibility of contamination of ground and surface waters in the surrounding area. Experimental work on evapotranspiration as a means of wastewater treatment and disposal has been carried out in Canada by Bernhart (1964) and Smith (1965) using highly impermeable soils as the membrane system. Several above-the-ground evapotranspiration systems for individual dwellings have been investigated by Witz, et al. (1970) and Lubinus and Barker (1971). These systems depend in part on infiltration. There is one commercially available system called the "Armon System" that uses a liner to prevent infiltration but also has an expensive treatment tank as part of the system.

This final project report gives information concerning an evapotranspiration system operated during the fall, winter and spring of 1974-75 which was built and tested previously during the summer months of 1973 and 1974 under a previous Eisenhower Consortium grant (Cooperative Agreement 16-354-CA) with the Rocky Mountain Forest and Range Experiment Station at Ft. Collins,

Colorado. Specifically, this present study (1974-75) was to evaluate whether or not an evapotranspiration unit could be operated during the winter months to treat domestic wastes to acceptable levels of purity and to determine the quantity of liquid waste which may be discharged into the unit during this period. In order to make these determinations, data are presented in this report on loading rates of wastewater, liquid elevation of the evapotranspiration unit and pollution parameters [biochemical oxygen demand (BOD), coliforms, and solids] which indicate level of treatment of the wastewaters.

THE EVAPOTRANSPIRATION UNIT

Location and Design Considerations

The evapotranspiration system or unit (referred to hereafter as an ET unit) is located north of Laramie, Wyoming,(Figure 1) at the site of the city waste treatment lagoons. The climate of Laramie is characterized by relatively low humidity (10-20 percent), mean wind speed of 5.0 miles per hour, mean annual rainfall of 11.1 inches, and mean annual temperature of 43^{0} F with a range from -35^{0} F to $+93^{0}$ F. The low mean annual temperature of Laramie is a result of its geographical location in southeastern Wyoming at an elevation of 7200 feet. The city itself is located on a high mountain plain which produces mainly short grasses and sagebrush. The site provides easy access to a source of wastewater and is in close proximity to laboratory facilities which are required for the study. It also meets many of the requirements of a second home dwelling in what might be considered a semi-primitive mountain environment.

Design, construction,and testing of the ET unit shown in Figure 2 was for a six-member family dwelling to be used during the summer months in semi-primitive high mountain areas. As stated previously, this ET unit was constructed during the summer of 1973 and tested during the summers of 1973 and 1974 under Eisenhower Consortium Cooperative Agreement 16-354-CA. The final project report of that project (Hasfurther, et al., 1974) is on file with the Rocky Mountain Forest and Range Experiment Station at Ft. Collins, Colorado. The report gives information concerning the construction,

Figure 1. The General Location Map Showing the Laramie Lagoons and the Evapotranspiration Unit with Respect to the Laramie Area.

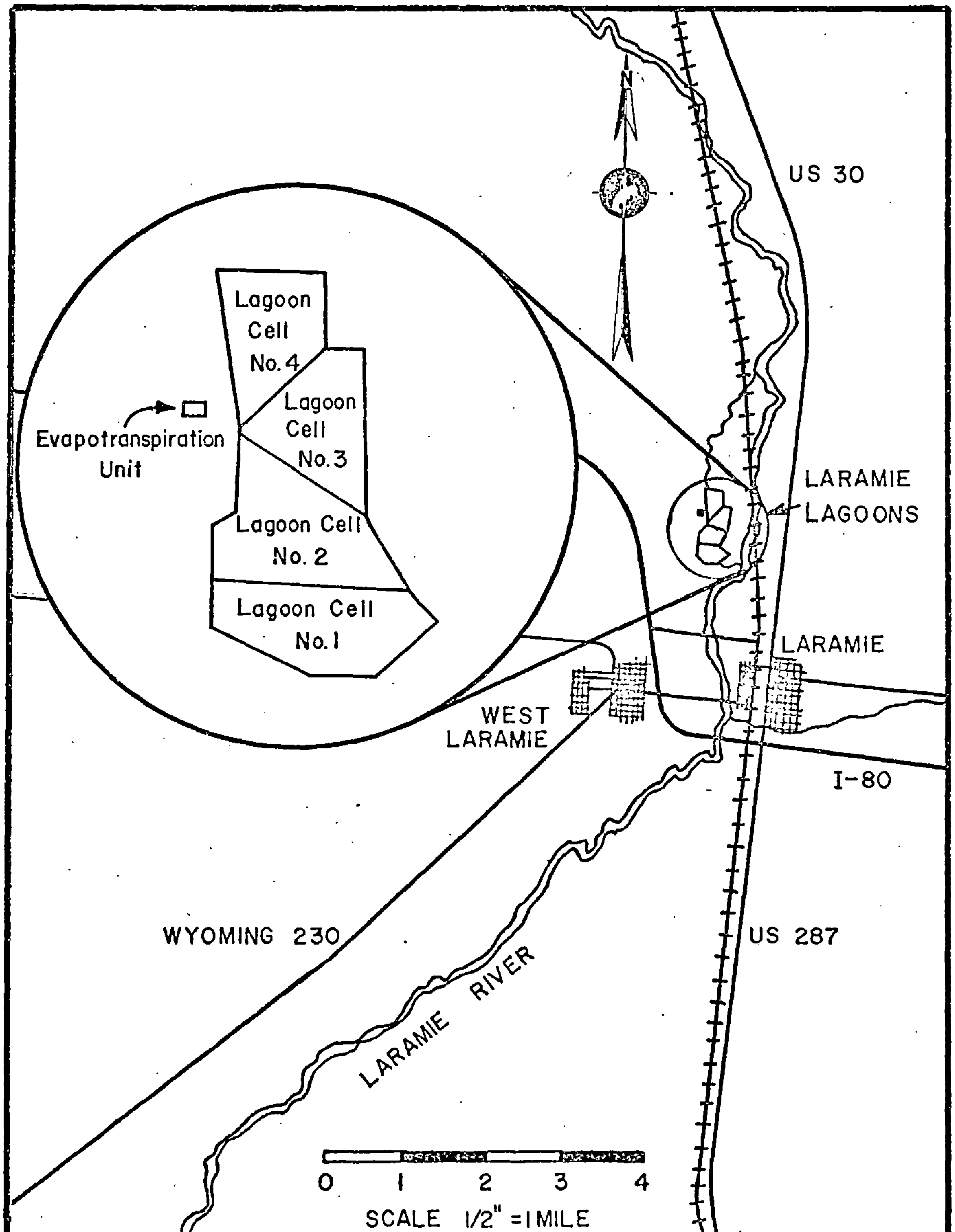
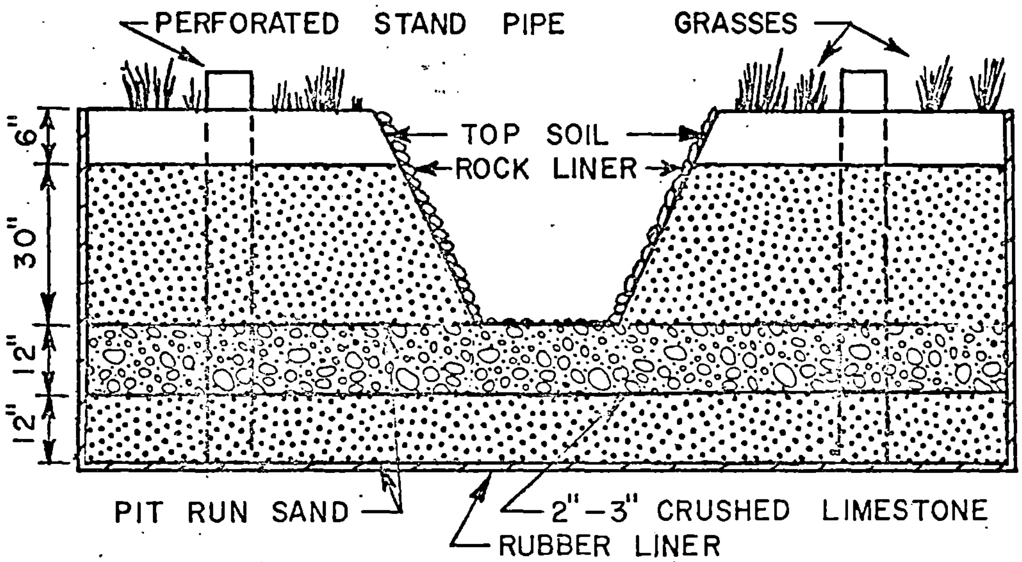


Figure 2. A Cross-sectional and Plan View of the Evapotranspiration Unit



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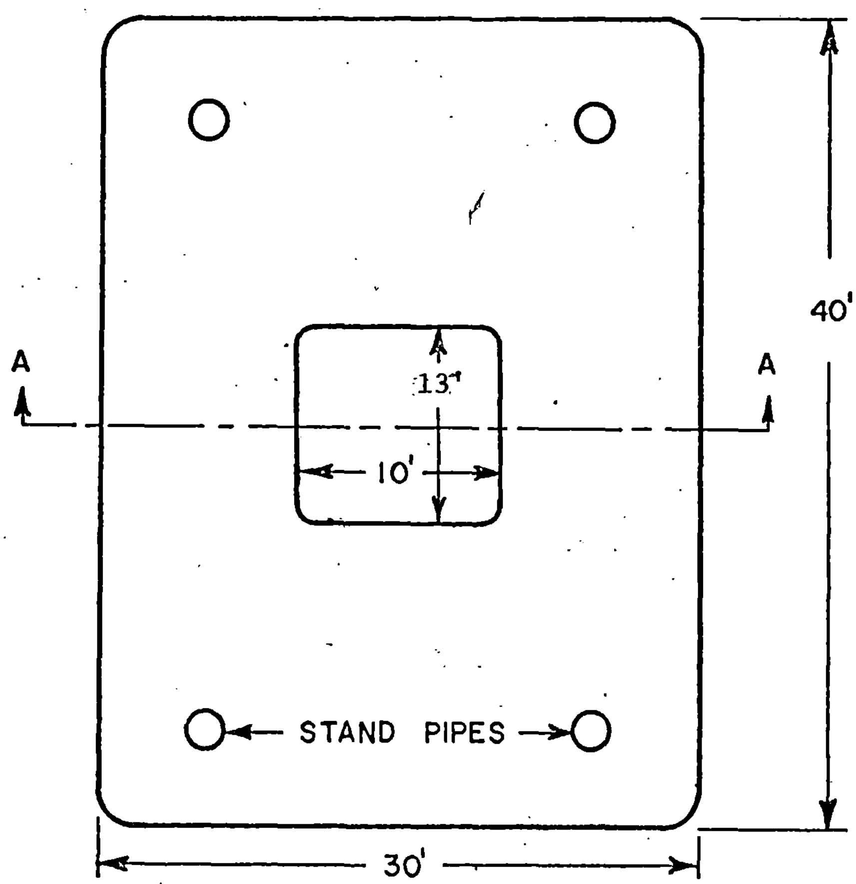

operation and loading levels, asthetic characteristics, sampling procedure and level of treatment of the wastewater, and cost of constructing and maintaining the unit.

Figure 2 indicates that the ET unit prevents any discharge of wastewater because of the reinforced rubber liner surrounding the unit. The material within the unit is sand and gravel with a six inch layer of topsoil. The sand and gravel are used to generate good dispersion of wastewater into the unit. The sand and gravel materials also were used to provide sufficiently large pore spaces to reduce the possibility of chemical, physical, and/or biological clogging (McGauhey and Winneberger, 1965; DeVries, 1972; Lance and Whisler, 1972; Thomas, et al., 1972; Jones, 1965; and Rice, 1974).

A mixture of grasses which included tall fawn fescue, orchard grass, reed canary grass, and alfalfa was planted in the six inches of topsoil on the unit. The selection of these grasses was based on representative types of grasses grown in the Laramie area, on varying root penetrations and on salt tolerance (Agriculture Handbook 60, 1954). By the fall of 1974 the unit was approximately 75 percent covered by grasses which consisted mainly of orchard grass, tall fawn fescue, and reed canary grass. Alfalfa did not thrive well in the wet condition of the soil, but a number of native grasses from the area surrounding the ET unit have seeded themselves within the unit. In September, 1975, the unit was approximately 85 percent covered with grass and the grass stood from two to six feet in height.

A ten foot by thirteen foot opening formed in the center of the unit (Figure 2) was lined with two to three inch diameter rock. The main purpose

of the opening is for entry of the influent wastewater, sampling and observation. Four 4-inch perforated standpipes, which extend the full depth of the unit, were placed close to the corners of the unit for sampling purposes.

Figure 3 shows the ET unit in the Fall of 1974. The surrounding area and one of the Laramie waste-treatment lagoons is in the background.

Figure 3. The ET unit in the Fall, 1974.

Loading and Sampling

Untreated wastewater for the ET unit is taken directly from a trunk sewer line and transported by truck to the unit where it is pumped into the center opening. Figure 4 shows the headbox and truck hauling system at the point where the untreated wastewater is collected for transportation to the ET unit.

Figure 4. Loading of the untreated wastewater for transportation to the ET unit.

The loading rate of the ET unit was varied during the course of this project investigation from a maximum of 2,000 gallons to a minimum of zero gallons in a seven day period. Actual loading was done on a five day basis (Monday through Friday) with no activity during weekends (Saturday and Sunday). From preliminary estimates of evapotranspiration which occur at Laramie during a typical summer (0.26 inches per day), the unit as constructed (1200 sq ft. of surface area) was to accommodate a family of six people in a second home dwelling based on a contribution per person of 50 gallons per person (Metcalf and Eddy, Inc., 1972) on a five day basis (i.e., 1500 gallons per week). From loading rates used in the previous Eisenhower Consortium grant, it was found that during the summer months (between freeze dates) the feasible loading rate for the unit lies between 1000 and 1500 gallons per week which indicates a required surface area

of 200 to 300 square feet per person. The actual loading rate which occurred during the fall, winter and spring months of this project (1974-75) varied greatly from what occurred and was expected during the summer months.

The loading rate is a function of actual evapotranspiration as well as sublimation during the winter season. Evapotranspiration depends upon a number of quantities for its maximum functioning. The factors which most influence evapotranspiration are solar radiation, temperature (which is a function of elevation), relative humidity (vapor pressure), wind speed, soil moisture available, plant density and surface area. Many of these same factors affect sublimation. Since a number of these quantities are influenced by geographic location, the Laramie site has particular advantages for such factors as solar radiation, wind speed and vapor pressure gradient. The main disadvantage of Laramie or any other high mountain site is the relatively low mean annual temperature which affects the length of the growing season and as a result plant growth and density. Also, sublimation is much slower at transferring water vapor to the atmosphere than is evapotranspiration and the low mean annual temperature of Laramie indicates that a large portion of the winter season experiences only sublimation.

A number of measurements were obtained at fairly regular intervals. The liquid elevation was monitored in each of the four standpipes located within the unit at least three to five times per week and always prior to injection of new influent wastewater to the ET unit. An elevation of 7200 feet was used as a base elevation for liquid level elevations. Figure 5 shows the measuring instrument used to determine the liquid elevations. The top of each of the four standpipes had a reference elevation with

respect to the base elevation of 7200 feet. In the background of Figure 5 is the reinforced rubber liner indicating the edge of the ET unit. Other measurements which were taken for reference data were air temperature, ET unit water temperature, and thickness of the ice layer in the center opening during the winter season.

Figure 5. Measuring instrument for liquid elevations.

Samples of influent wastewater and effluent wastewater (that wastewater retained by the ET unit which has not evaporated or transpired to that point in time) were taken as deemed necessary by the loading of the unit and weather conditions during the fall, winter and spring months. Summer time operation for sampling was handled on a regular basis of three to five times

per week. The influent and effluent wastewater samples were tested for BOD, coliforms, and dissolved and suspended solids.

OPERATION OF THE ET UNIT

The operation of the ET unit is based on the period from July 19, 1974, to August 15, 1975. The main emphasis of the operation will be placed on the fall, winter and spring months. The loading and liquid elevation of the unit are important to the operation of the unit and as a result the data on these two quantities will be presented in this section. A slight overlap of data between the previous Eisenhower Consortium report and this report results to ensure that all data from the two projects are presented. The data reported are based on weekly averages in most cases.

Figures 6 and 7 show the weekly amount of influent liquid loaded into the ET unit and the average weekly liquid elevation of the ET unit over the period of operation. The weekly influent loading rates are actual wastewater added to the unit and as a result any precipitation which occurred during the same period of time is in addition to the amounts indicated. The amount of precipitation and the time at which it occurred during the period of operation of the unit is shown in Table 1. From a laboratory analysis of the sand and gravel in the unit, it was determined that a 1.0 inch rainfall over the unit would increase the liquid level in the unit approximately one-third of a foot.

The ET unit was operating at a loading rate of 1000 to 1500 gallons per week during most of the summer season of 1974 and the liquid elevation of the unit remained fairly constant. However, during the week ending July 26, 1974, the liquid loading rate was increased to 2000 gallons per week. It was noticed that the liquid elevation of the unit rose

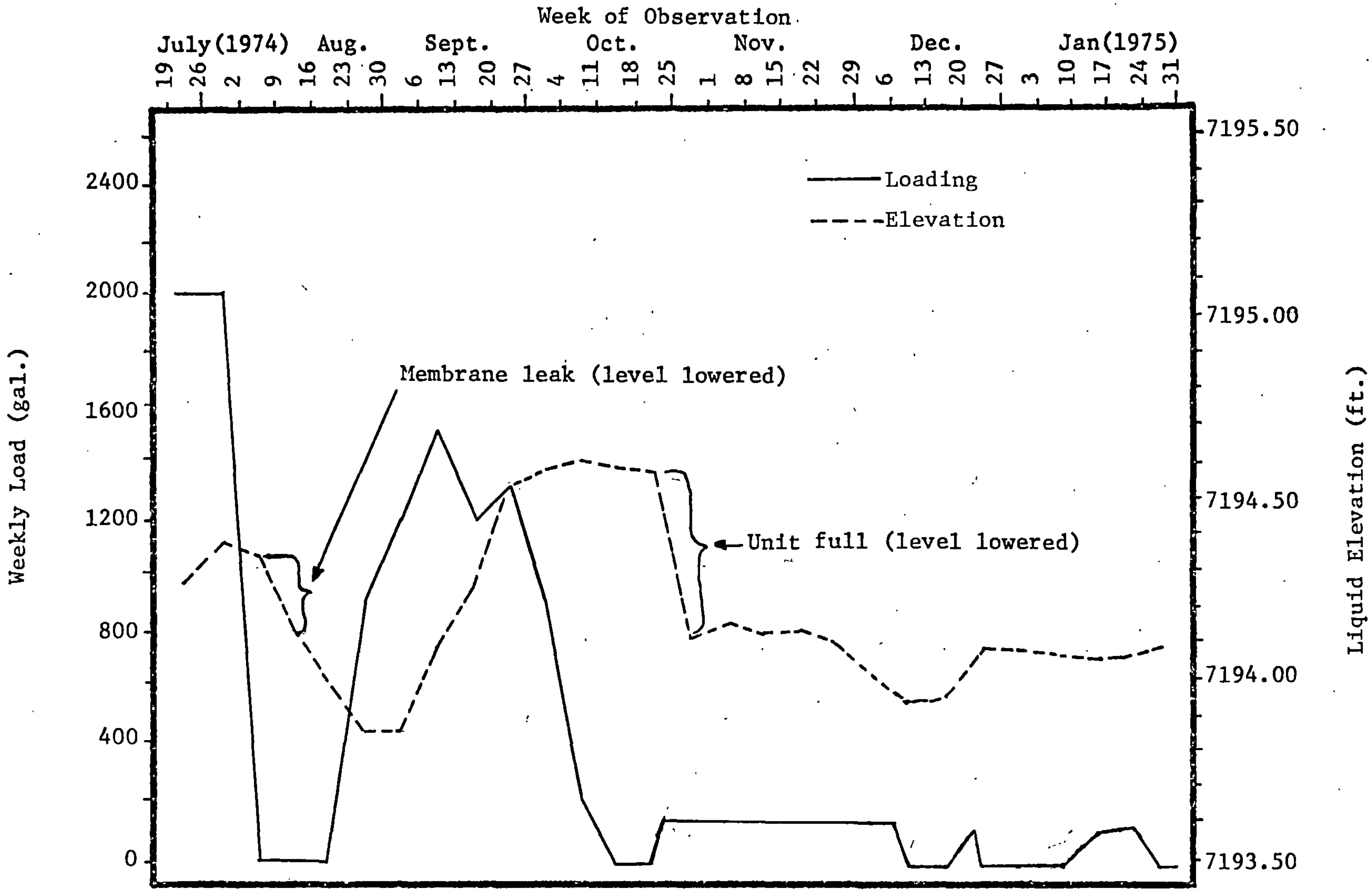

Figure 6. Liquid Elevation and Loading Rate (July 1974 through January 1975).

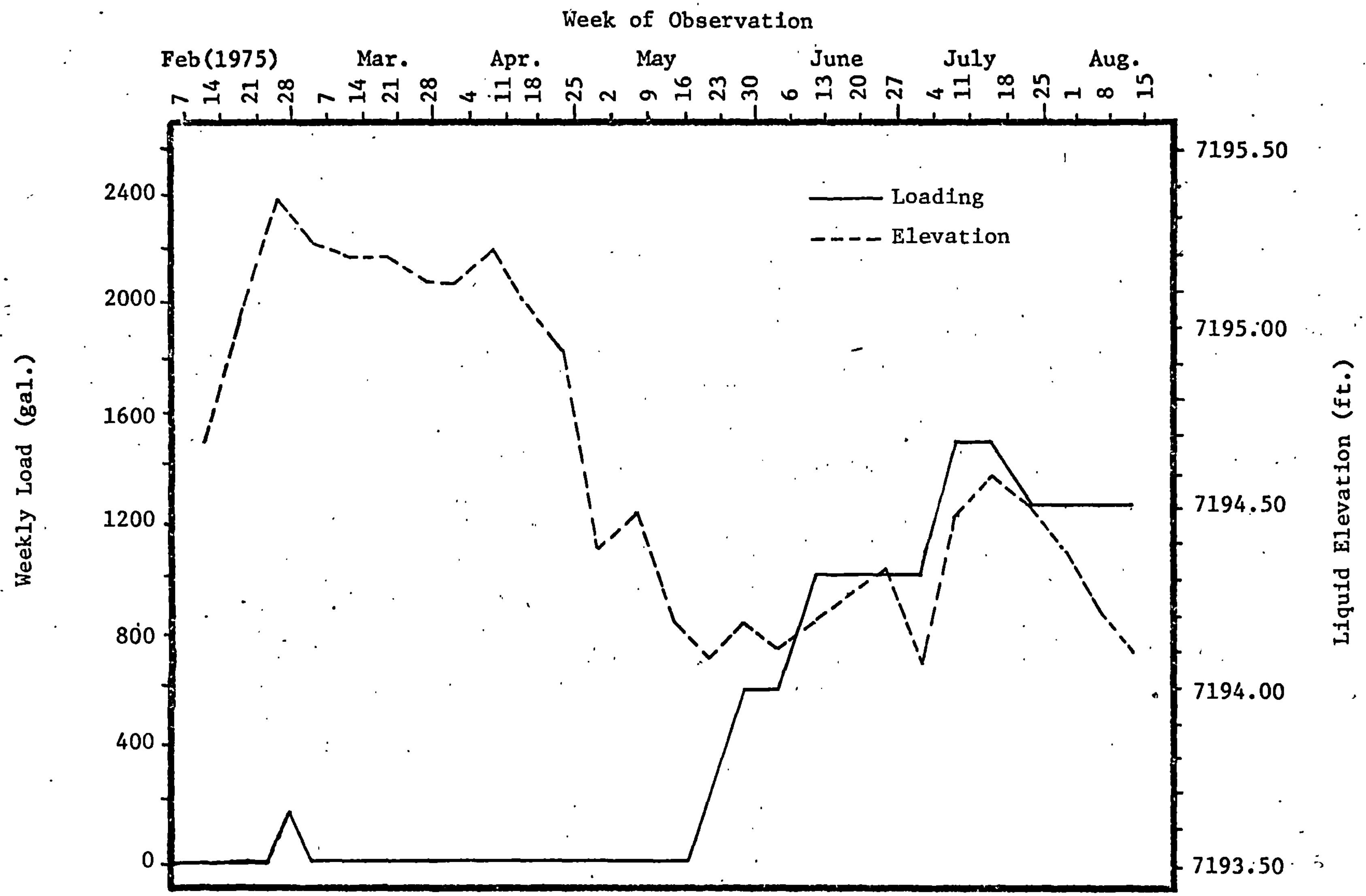

Figure 7. Liquid Elevation and Loading Rate (Feb. 1975 to August 1975).

Table I

Weekly Precipitation Measured at Laramie
(Laramie 2 NW)

Week Ending	Precipitation Amount (Inches)	Week Ending	Precipitation Amount (Inches)
7/19/74	0.28	2/7/75	.06
7/26/74	0.65	2/14/75	0
8/2/74	0.66	2/21/75	.13
8/9/74	1.12	2/28/75	0
8/16/74	.07	3/7/75	.02
8/23/74	0	3/14/75	.11
8/30/74	0	3/21/75	.23
9/6/74	.07	3/28/75	.35
9/13/74	.42	4/4/75	.11
9/20/74	.02	4/11/75	.06
9/27/74	0	4/18/75	.10
10/4/74	.02	4/25/75	0
10/11/74	.15	5/2/75	.22
10/18/74	.50	5/9/75	.36*
10/25/74	.72	5/16/75	.20*
11/1/74	.31	5/23/75	.90*
11/8/74	.10	5/30/75	.24
11/15/74	.32	6/6/75	.28
11/22/74	0	6/13/75	.27
11/29/74	.25	6/20/75	.08
12/6/74	.10	6/27/75	.28
12/13/74	.05	7/4/75	0
12/20/74	0	7/11/75	1.75
12/27/74	0	7/18/75	.19
1/3/75	0	7/25/75	.33
1/10/75	0	8/1/75	.10
1/17/75	0	8/8/75	---
1/24/75	.28	8/15/75	---
1/31/75	.11		

*Adjusted using stations in the Laramie area

quickly to a high level (7194.40) and remained fairly steady at this level with the same loading through August 2, 1974. During this period of time it was noticed that plants and grasses just outside of the ET unit on the west side started to turn quite green in color. The rubber liner was not visible in this area and as a result excavation at the liner area revealed that the liner elevation was at approximately 7194.40. It was determined that the liner was mishandled during construction and as a result when the liquid elevation reached approximately this level, the fluid discharged outside the unit. The liquid level in the unit was then reduced during the week of August 9, 1974, (Figure 6) and excavation of the topsoil and sand next to the liner was removed for repair of the rubber membrane liner. The drying period required and the glue used to fuse a new piece of liner with that already in place took approximately two and one-half weeks. During this two and one-half week period the liquid elevation dropped appreciably.

Loading of the unit was again undertaken during the week of August 30, 1974, and was loaded at various rates (Figure 6) until the week ending October 11, 1974. The liquid elevation of the unit made a steady climb during this period even though the loading rate was not excessively high. If one looks at the air temperature data, however, on September 3, 1974, the temperature dropped below 32^{o} F for the first time in Laramie. The low temperature on that date was a very cold 13^{o} F which is a killing frost for most all plants and grasses. It is believed that this killing frost along with the steady cold low temperatures which continued during the month of September reduced the evapotranspiration of the unit appreciably. The cold freezing temperatures which reduced the evapotranspiration

can thus explain the steady rise in liquid elevation which occurred during September and part of October in the unit.

From October 11 to 25, 1974, the unit was filled to what was felt was reasonable capacity and no influent wastewater was added. During this period of time also, approximately 1.3 inches of precipitation fell on the unit. In order to see if a level of loading could be determined for the months following October, the unit was lowered by pumping effluent from the center opening during the week of October 25 to 30, 1974 (Figure 6).

For the period from November 1, 1974, to December 6, 1974, the unit was loaded at an average rate of 150 gallons per week. The liquid elevation in the unit actually declined slightly during this period (Figure 6). Ice began to form in the center opening of the unit at nights for this period starting early in November. It would thaw during the daytime. The ice in the center opening finally froze for the entire day on the second of December. Due to the insulation effect of the soil and sand, ice was not noticed in the standpipes until December 6 and then in only one of the four pipes.

It was felt that in order to evapotranspirate and sublimate enough water to keep the unit operating at a reasonable level, the center opening and the entire unit should be free of ice as long as possible. The addition of higher temperature influent wastewater (higher than the water in the unit) should generate heat. Also, the organic load added to the unit would result in more bacteriological activity and thus heat generation. To aid in the development and holding of heat by the unit, a frame structure similar to a hot house was constructed covering the center opening (Figure 8). The temperature on the average inside

the hot house structure was 2 to 3^{o} C, warmer (from actual measurements collected) than the outside surrounding air. This temperature difference it was felt helped to keep the water in the center hole from freezing completely during November when temperatures were moderate. When the temperatures dipped low in December, however, the frame structure really had little effect on the unit because of the far below freezing temperatures which occurred. The structure did serve as a shield to prevent drifting snow from filling the center opening completely during the rest of the winter. Since the amount of influent was small, the amount of heat input to the system was found to be far below that necessary to keep the unit operating at a reasonable loading rate. The result as stated previously was a complete freezing of the unit.

Figure 8. Frame Structure Similar to a Hot House Placed Over the Center Opening.

A heater system (stockwater space heater) which inputs heat to the water directly was also tried during the week of December 13, 1974. The amount of energy input to the system was appreciable and the water temperature was never raised appreciably in the unit. It was concluded from this experiment that costs would prohibit trying to keep an ET unit of this size being tested in this research project free from ice.

Once the ET unit had completely frozen throughout, this occurred on December 23, 1974, the amount of evaporation, transpiration and sublimation was small as indicated by the amount of influent wastewater which was capable of being loaded into the unit between the middle of December 1974 and the middle of May 1975 (total of 550 gallons, Figures 6 and 7). Figure 7 shows that the liquid level in the standpipes increased as influent wastewater was added during this period of time. It was interesting to note also that as the ice layer in the unit became thicker and thicker (reached its maximum thickness on February 28, 1975, at 2.4 feet), the liquid elevation was continually increasing. Another interesting phenomenum was the fact that the unfrozen water in the unit was placed under pressure as a result of the ice thickening. When samples of effluent could be obtained by rodding through the ice layer, the water would gush out the hole created when the ice-water layer was penetrated. During this period of time also (December to May), it was very difficult to get real accurate readings on the water levels in the standpipes.

Blowing snow seemed to be attracted to the unit over the December to May period because of the good stand of dead grass blades and the frame structure. This resulted in much higher amounts of water due to

snow melting on top of the unit than was actually precipitated during this period. In fact in the early part of April the center opening was completely filled with ice as a result of the snow melting during the day and freezing at night. It is interesting to note that the liquid elevations actually began to decline in March and April in the standpipes of the unit (Figure 7) even though the center opening was being overtopped by the melting drifted snow.

Just as the sand, gravel and topsoil act as an insulator to keep heat from transferring out of the unit in the fall and thus keeping the water body open longer during that period of time, these same materials also act to keep the unit from thawing as quickly as the surrounding water bodies in the spring of the year. The Laramie City lagoon ponds were open two to three weeks before the ET unit thawed.

The operation of the unit from May 12, 1975, when the unit was again completely liquid, until the end of data collection on August 15, 1975, was similar to the procedure described in the previous Eisenhower Consortium project. The loading rates used again show that the unit is capable of handling between 1000 to 1500 gallons per week of influent wastewater during the summer months.

As part of the operational procedures of the unit, esthetic qualities of the unit were monitored. Esthetic qualities observed during the operation of the unit were cover, odors, insects and algal growths. The only odor really noticeable during the project was sulfur dioxide which had collected in areas inside the frame structure during the winter months. Around the unit no odors were detectable. The grasses and the unit as

a whole during the summer give insects such as mosquitos a hiding and perhaps breeding place (no larvae of any size has been observed). A few algal blooms occur during the summer but do not seem to be esthetically prohibitive. As a result, it is believed that people would find the unit esthetically pleasing.

WASTEWATER TREATMENT RESULTS

One of the major objectives of this study was to obtain information on the treatment of domestic wastes by the ET unit. In trying to obtain information to help in determining treatment, samples of influent and effluent wastewater were obtained over the period of the project. The quantities analyzed from the water samples were BOD, total coliforms, total solids, total volatile solids, total dissolved solids, total volatile dissolved solids, total suspended solids and total volatile suspended solids. The samples obtained during the fall, winter and spring parts of this project were far less than on a regular basis. Reasons for this were availability of data collectors and analyzers, incomplete and inexperienced analyzers of collected samples, and weather conditions at the site for obtaining sample data.

It should be indicated again that the ET unit has no effluent as such, but it is important that the portions of the wastewater which can be broken down by the action of bacteria within the unit be degraded. Without some means of removing the degradable portions of the wastewater, these materials would accumulate and eventually clog the unit rendering it useless. The pores in the sand and gravel must be kept open to allow the liquid to move to the surface of the unit and be carried away by evaporation, transpiration or sublimation.

BOD is a measure of the oxygen required by bacteria to break down organic matter present in wastewater. Thus, it may be regarded as an indirect measure of the organic matter present. Using recognized standard

procedures (A.P.H.A., 1972), the influent and standpipe or center opening (depends on which one is accessible) liquid were analyzed for BOD substances. Figures 9 and 10 show the amount of removal of organic matter present. Irregular observation indicated on Figures 9 and 10 means that only one or perhaps two values were all that were measured during that interval of time. Removal varied widely with time but did not appear to be related to the quantity of wastewater organic matter. This indicates an insensitivity to shock loads which is a definite advantage for recreational treatment systems.

Figures 11 and 12 indicate coliform removal. Coliforms are a group of bacteria present in the intestine of warm blooded animals. Their presence in water is regarded as an indication that fecal contamination may have occurred and the water could possibly harbor disease producing agents. Removal of coliforms is consistently above 90 percent. However, the quality of the liquid reaching the standpipes would not be considered acceptable for recreational or other domestic uses. It is interesting to note that the die off rate continues during the winter in a manner of continual removal during periods of little or no influent.

Total solids and total volatile solids are shown in Figures 13 and 14 and 15 and 16, respectively. Their usefulness is as an indicator of total solids load present in the unit and as such a comparison to total solids load in similar type units.

Total solids are divided into dissolved and suspended solids materials present in the wastewater. Part of each category may be considered to be volatile, that is, it is made up of combustible or organic substances.

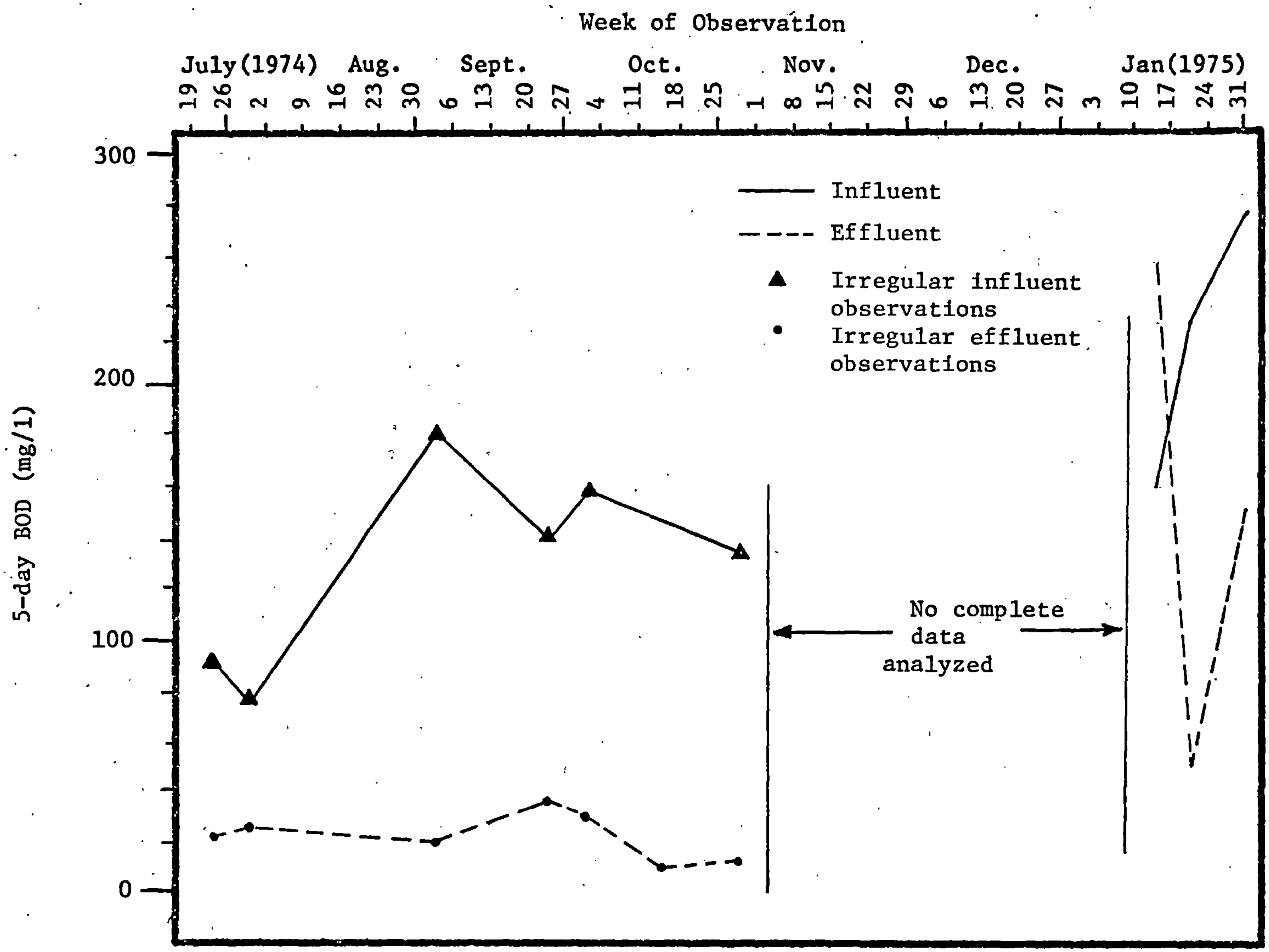

Figure 9. Biochemical Oxygen Demand (July 1974 through January 1975).

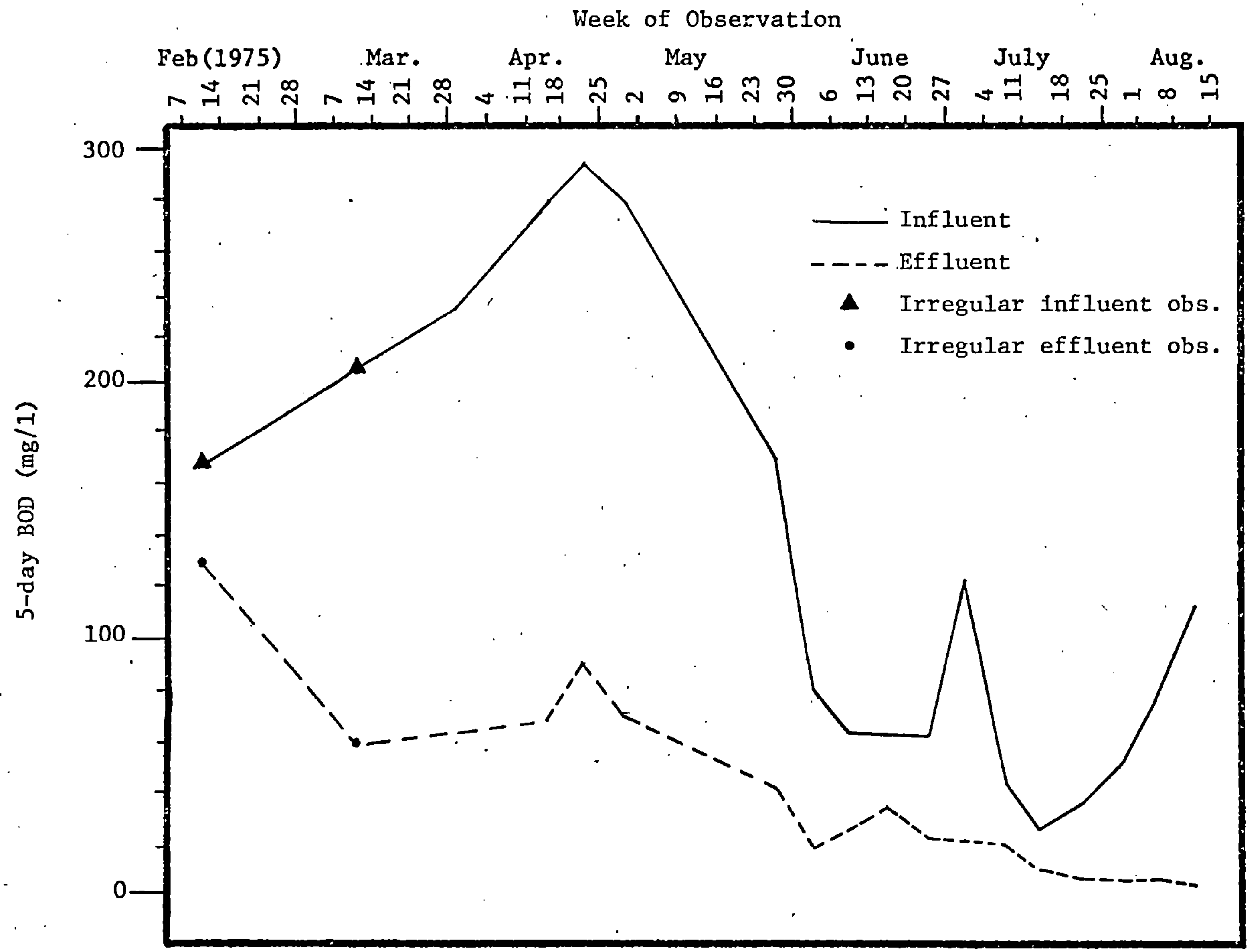

Figure 10. Biochemical Oxygen Demand (February 1975 to August 1975).

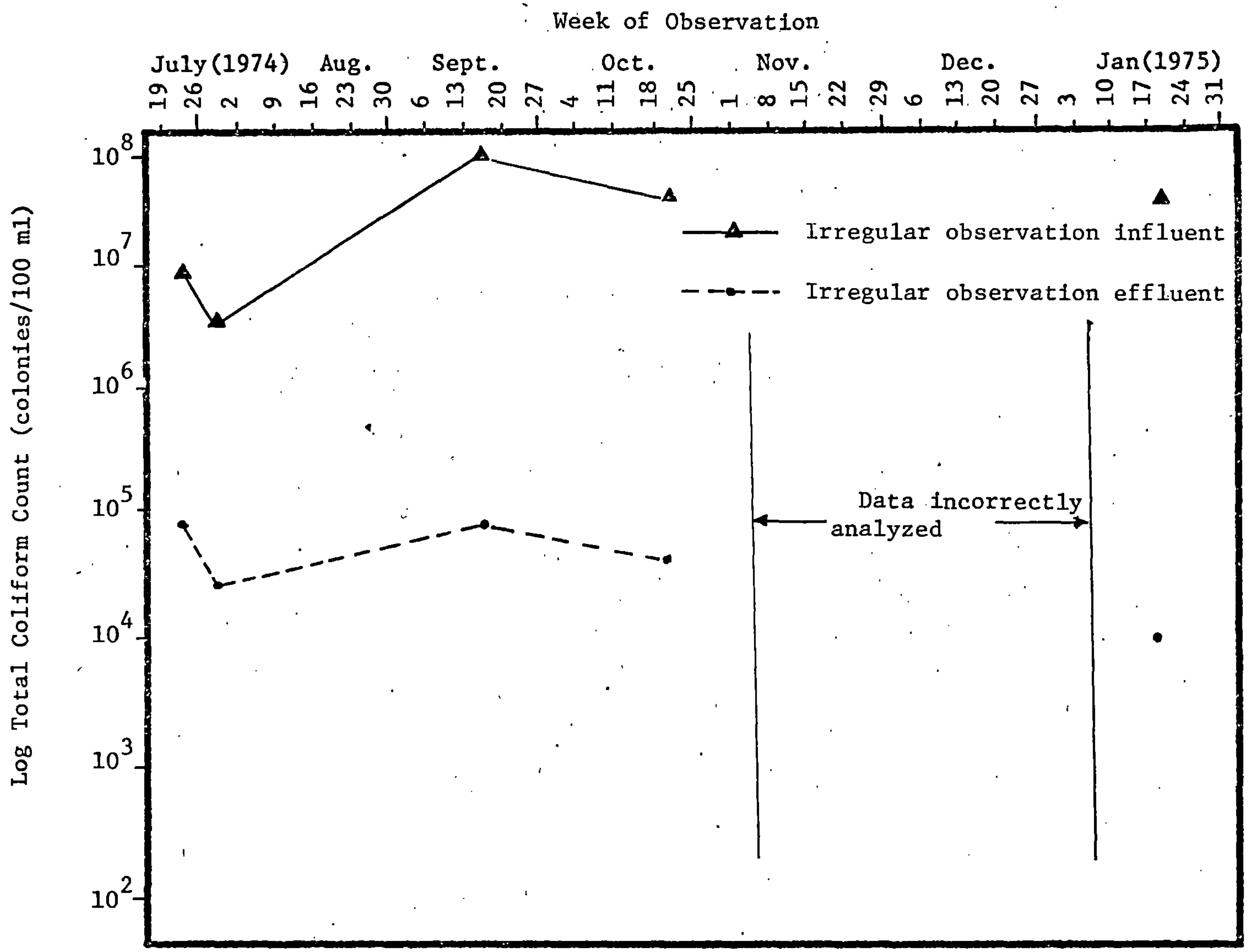

Figure 11. Total Coliform Count (July 1974 through January 1975).

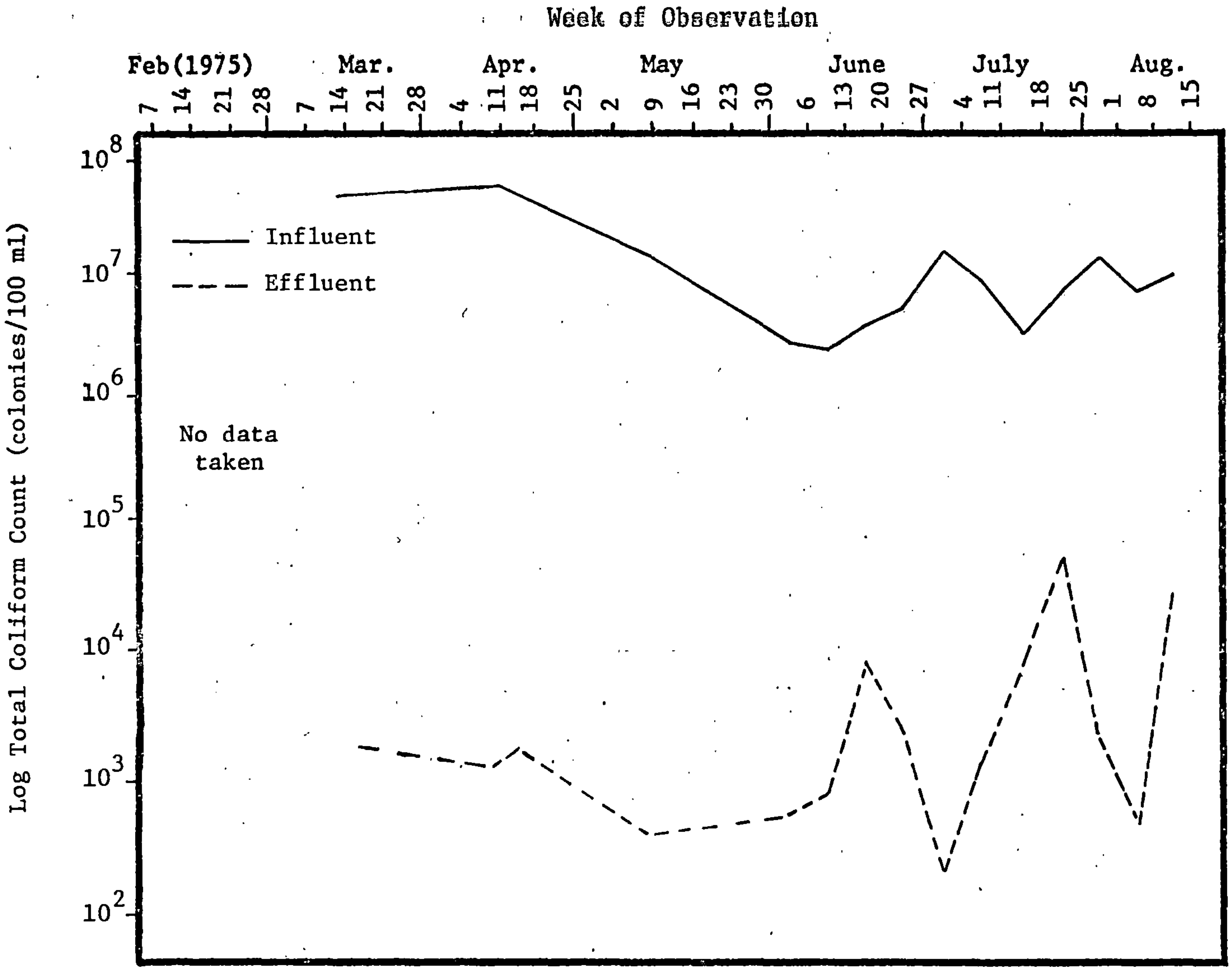

Figure 12. Total Coliform Count (February 1975 to August 1975).

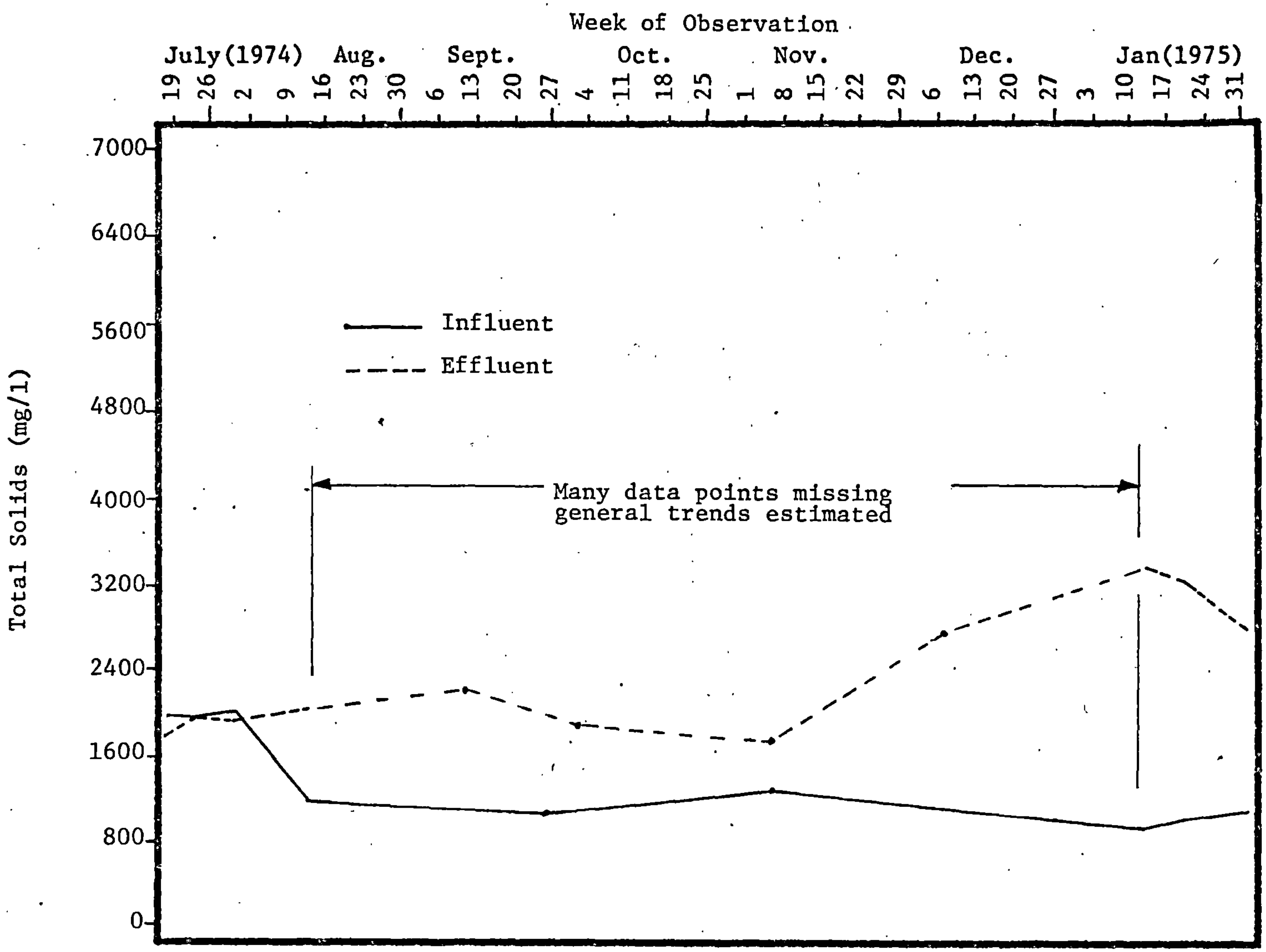

Figure 13. Total Solids (July 1974 through January 1975).

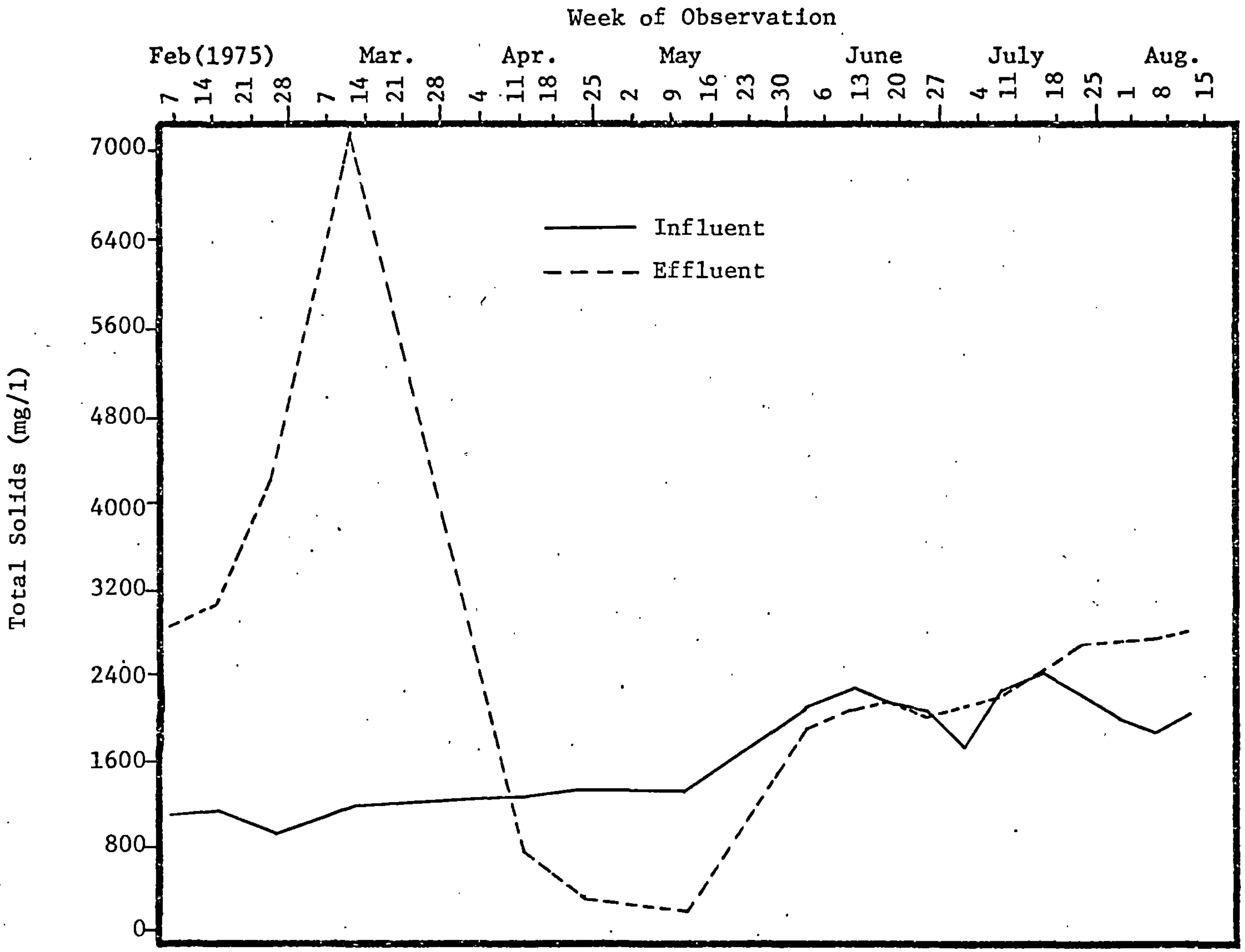

Figure 14. Total Solids (February 1975 to August 1975).

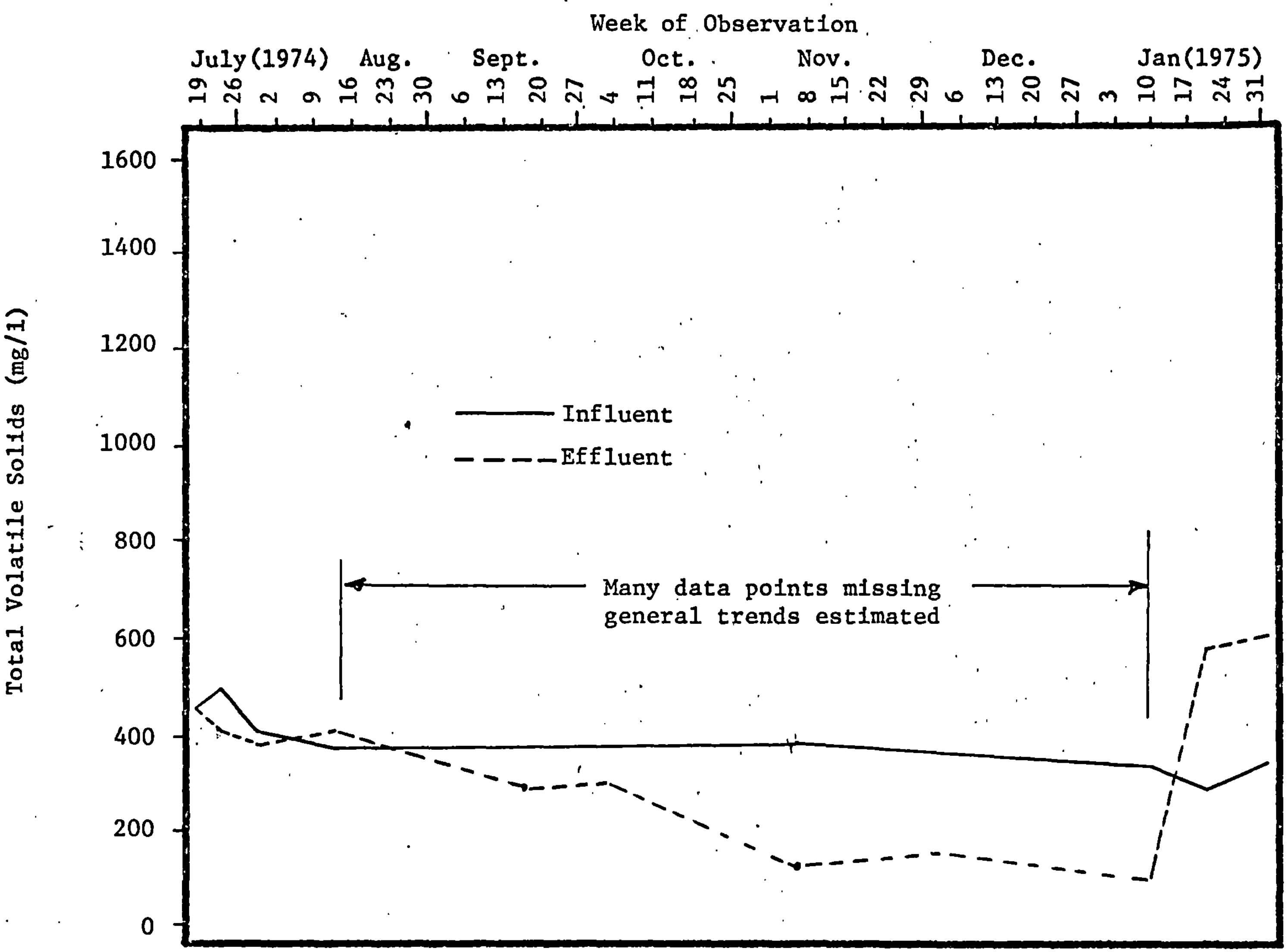

Figure 15. Total Volatile Solids (July 1974 through January 1975).

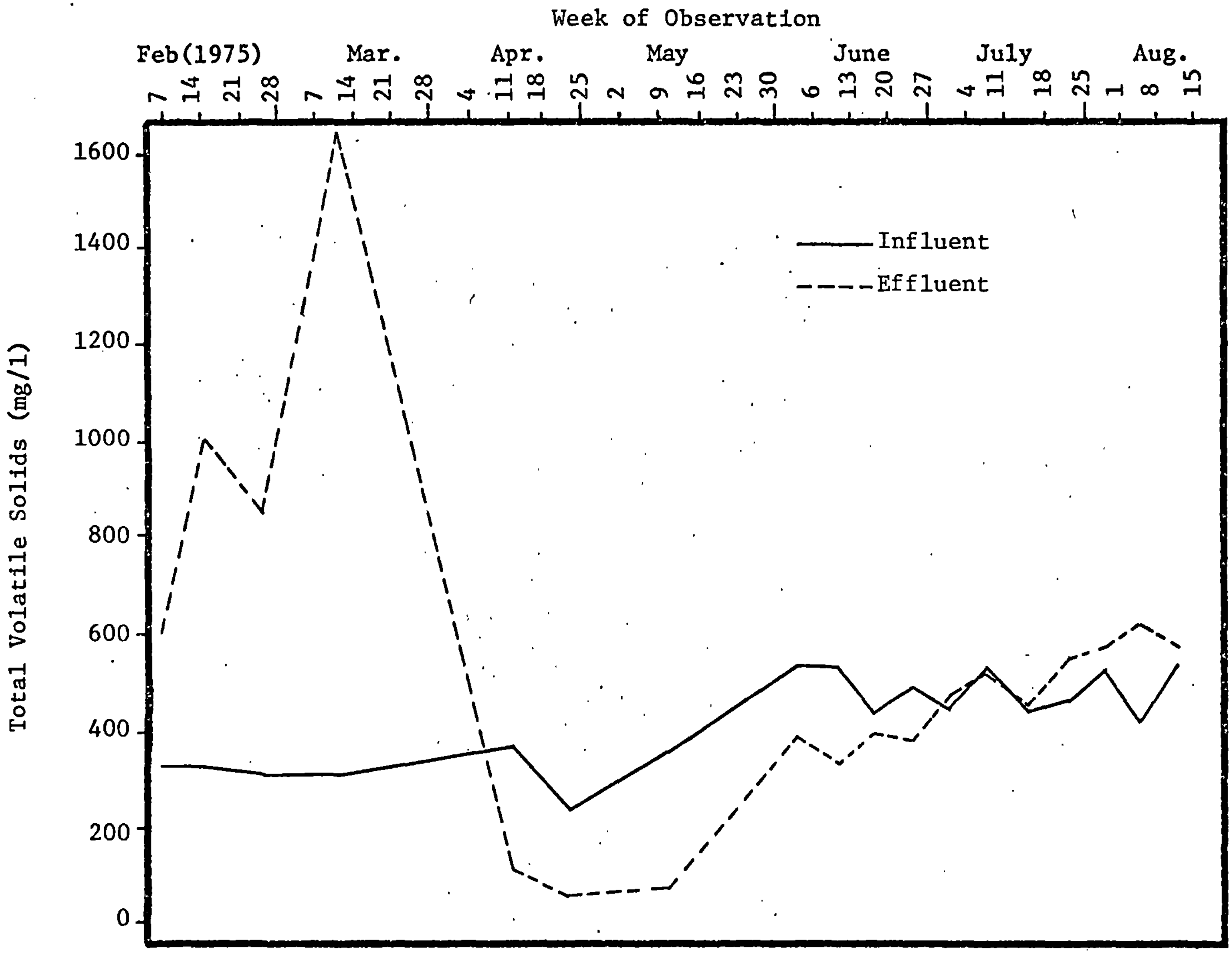

Figure 16. Total Volatile Solids (February 1975 to August 1975).

Total dissolved solids or dissolved solids are inorganic substances, principally salts, which may combine with soil particles in such a way that the soil becomes less permeable to water (McGauhey and Winneberger, 1965; DeVries, 1972; Lance and Whisler, 1972; and Thomas, et al., 1972). In the ET unit the salts present in the wastewater are left behind when the water leaves the unit by evapotranspiration and for the most part these salts will not be broken down by biological action. As a result, salts should tend to build up in the unit and over a period of time reduce the lifespan of the unit. Figures 17 and 18 show the dissolved solids which were measured in the unit. The general trend is that the effluent wastewater dissolved solids are consistently above the influent dissolved solids and slowly rise as would be expected. However, in February, 1975, (Figure 18) the dissolved solids increase sharply and continue to do so into March and then do a complete change from the middle of March into May. There is a plausible explanation for this occurrence. The effluent water samples had to be obtained during this period from the center opening because the standpipe's waters were completely inaccessible. As the ice thickness increased in the unit putting the water under pressure, the water sample being obtained is coming closer and closer to the sand and rock layer approximately three feet below the top surface of the unit. The water collected for the sample is a result of the gushing flow through the opening made with the ice rod and as the water moves toward and enters the hole, its velocity is great enough to entrain the solid material lying on the bed of the rock and sand layer. This results in

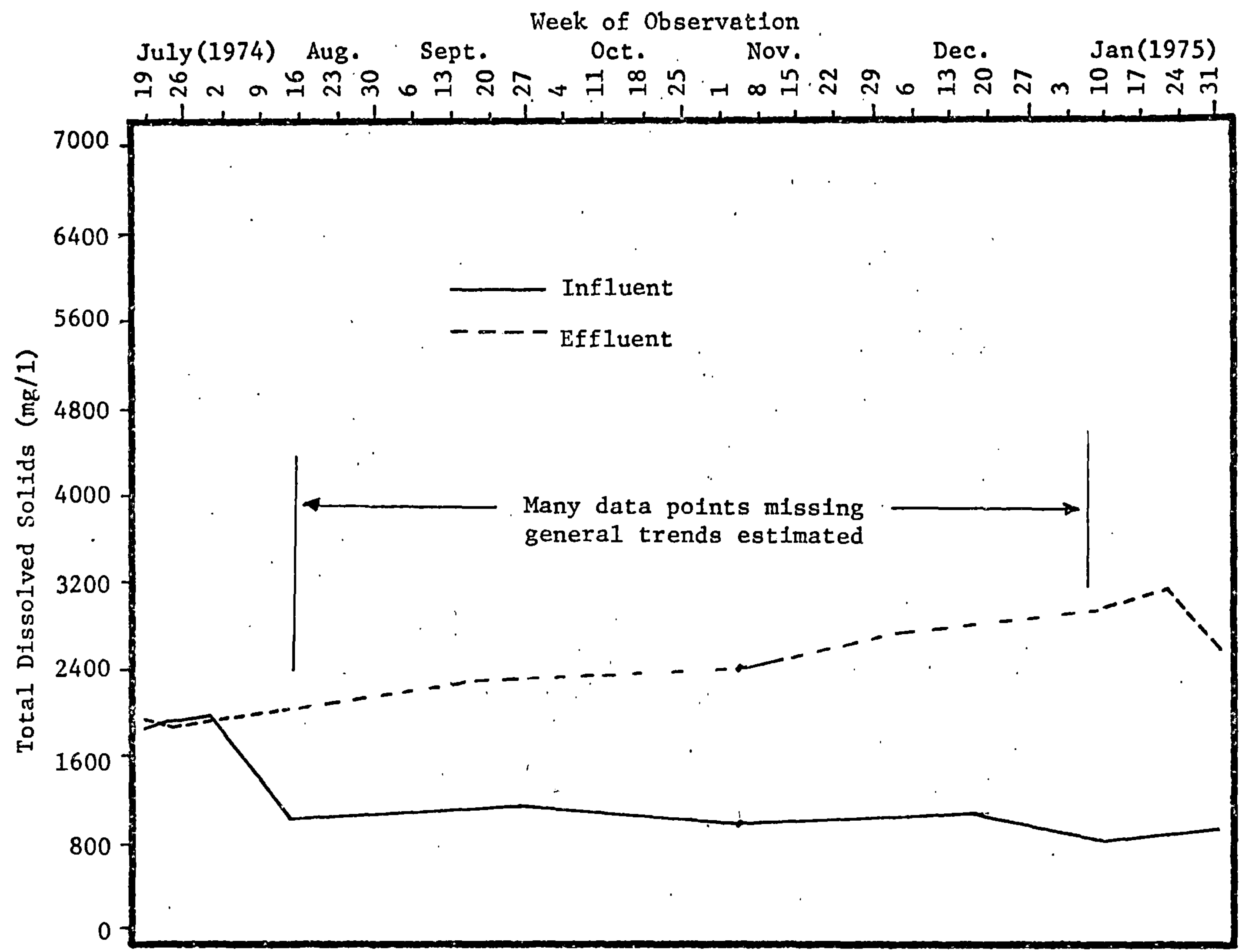

Figure 17. Total Dissolved Solids (July 1974 through January 1975).

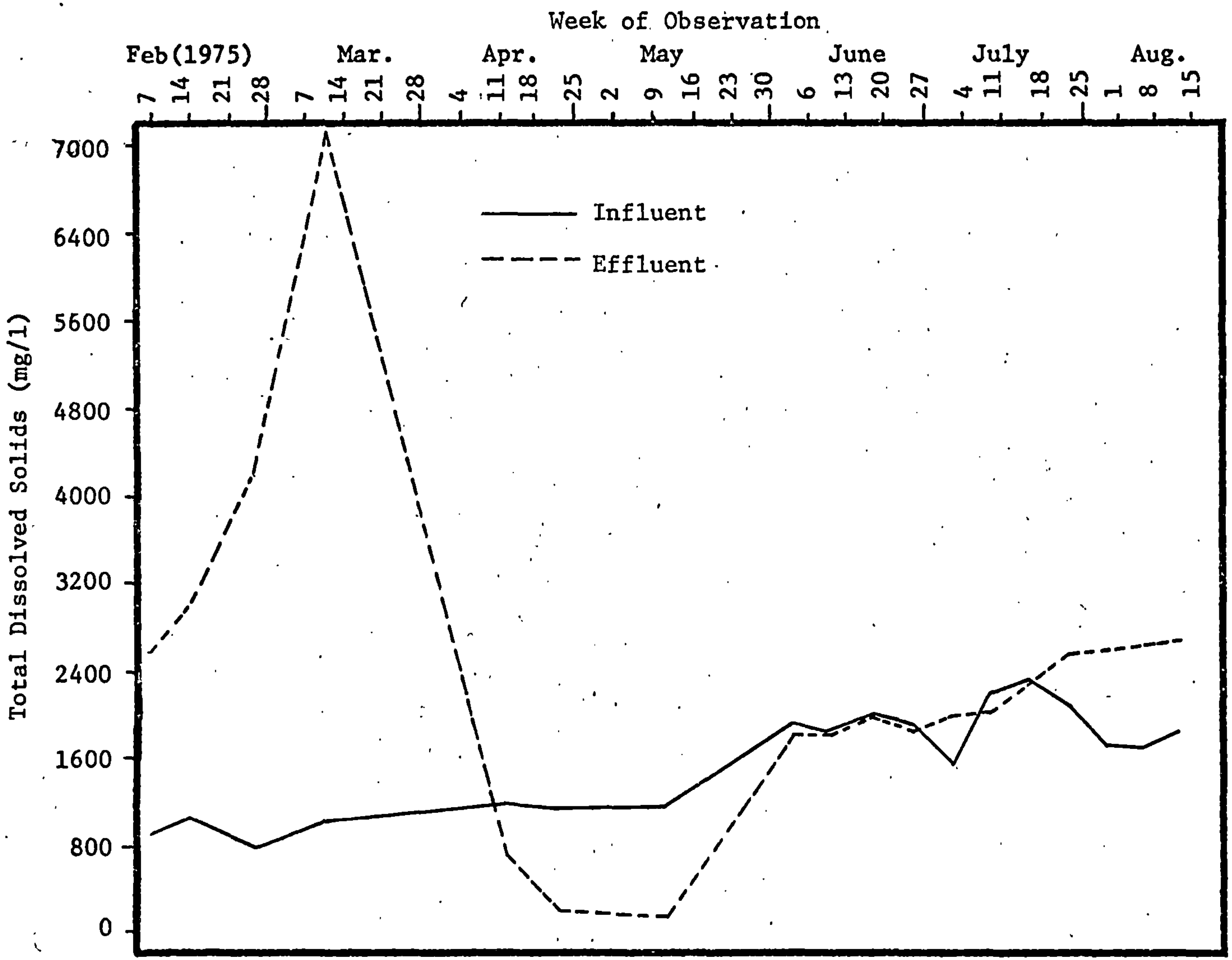

Figure 18. Total Dissolved Solids (February 1975 to August 1975).

the high dissolved solids which occurred in February and March. The drastic decrease in dissolved solids from March through April results from the ice melting and the dissolved solids being settled out as a result of the dissolved solids combining into solid particles during the freezing process (one mechanism of purifying highly saline water). The water which is now being sampled has become more dilute as time passes, resulting in the decrease. Thus, the data collected does not indicate the true relative trend of the dissolved solids during this period of time. An overall increase in salts at the standpipes of the unit is observed by comparing July of 1974 with July of 1975. However, the amount of salts build-up is small and should not influence the growth of grasses on the unit for sometime in the future. Total volatile dissolved solids or volatile dissolved solids are shown in Figures 19 and 20, and indicate the same conditions as the dissolved solids.

Total suspended solids or suspended solids are important because the particulates have a tendency to clog soil pores. With time, pores could become so thoroughly blinded as to render the unit useless unless the solids can be broken down. The volatile suspended solids represent the biodegradable portion of the suspended material. Total suspended solids are shown in Figures 21 and 22, and indicate that removal occurs in the unit between the center opening and the standpipes as a result of the filtering action of the medium during the entire year except on one or two isolated occasions. With this removal, no severe clogging problem has been apparent.

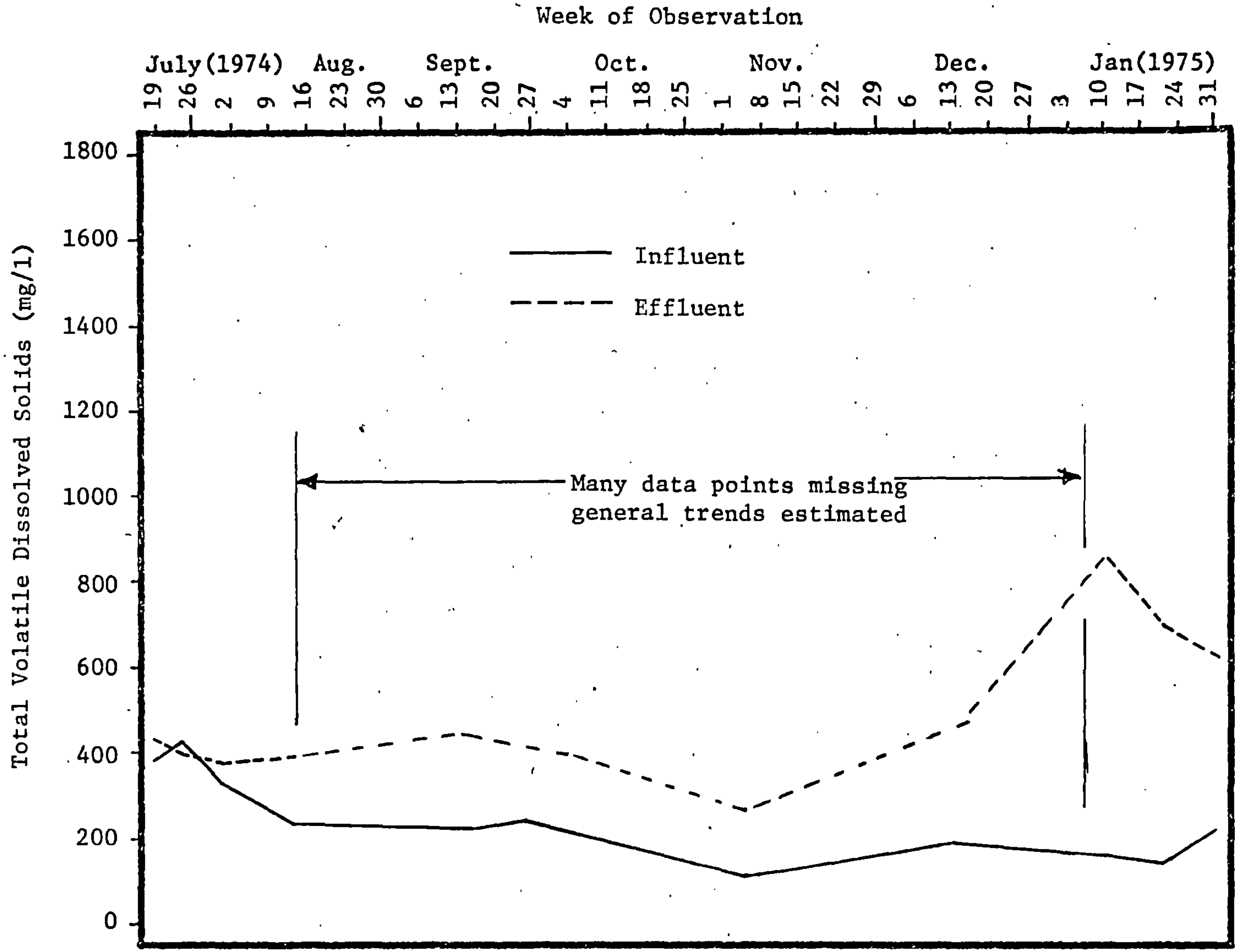

Figure 19. Total Volatile Dissolved Solids (July 1974 through January 1975).

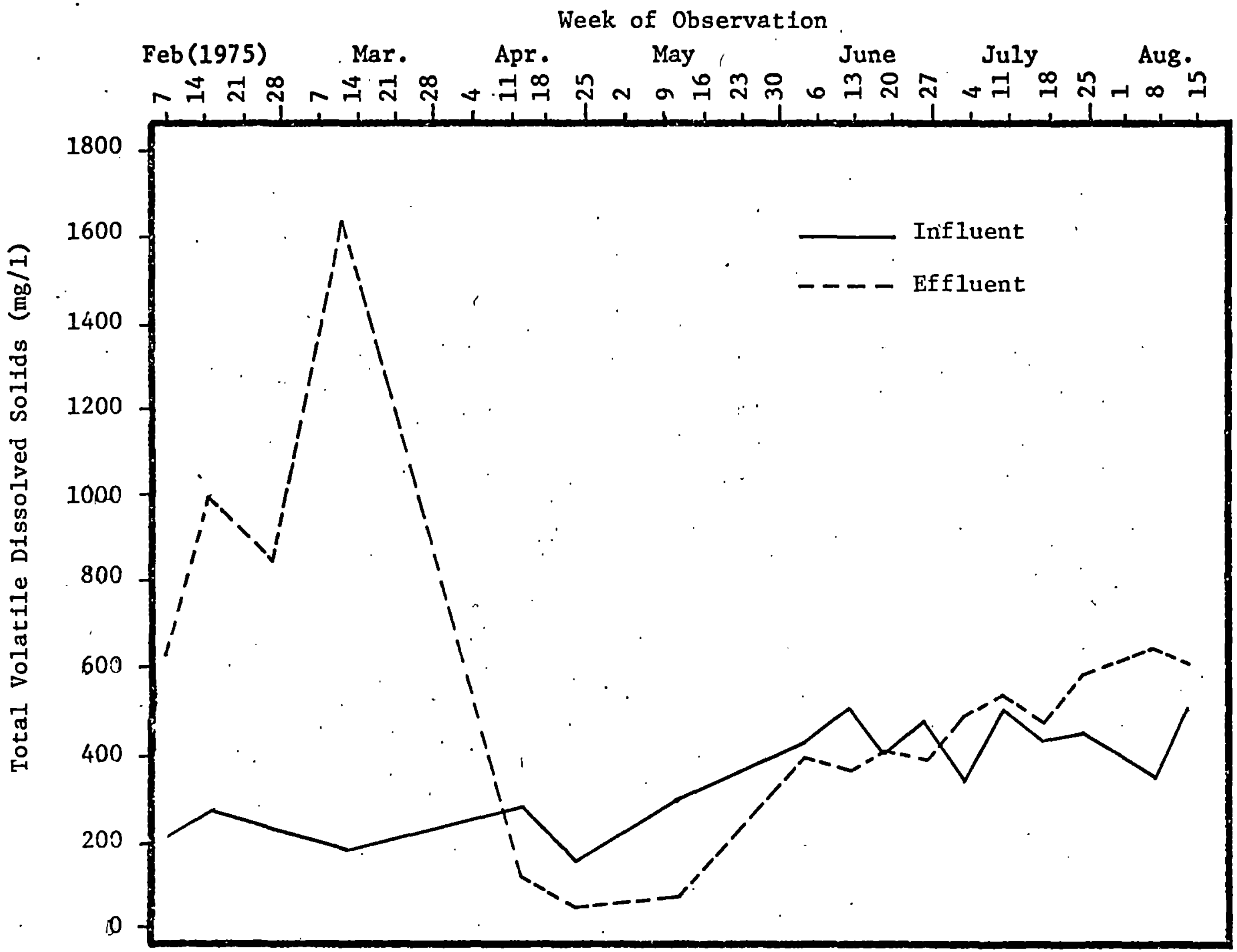

Figure 20. Total Volatile Dissolved Solids (Feb. 1975 to August 1975)

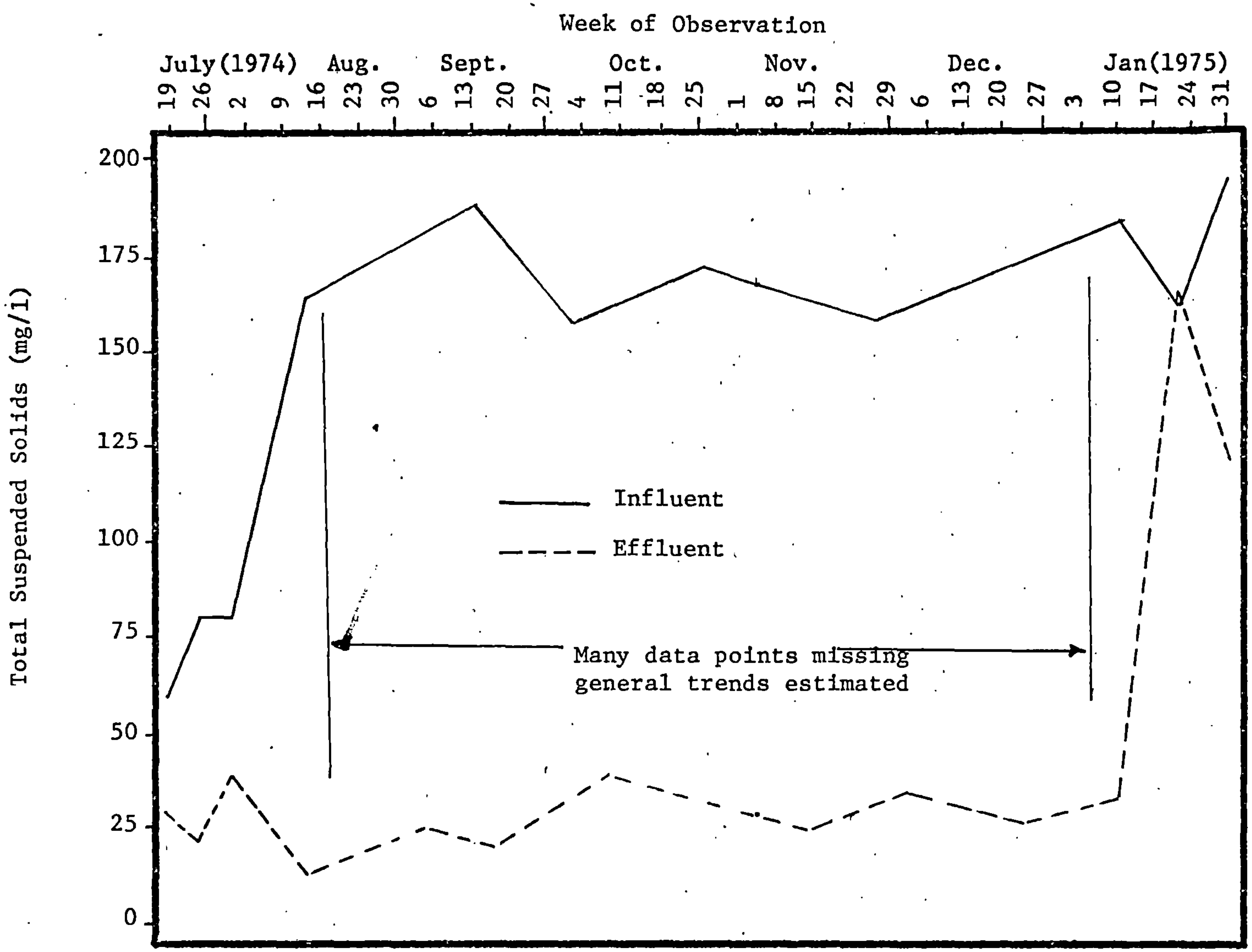

Figure 21. Total Suspended Solids (July 1974 through January 1975).

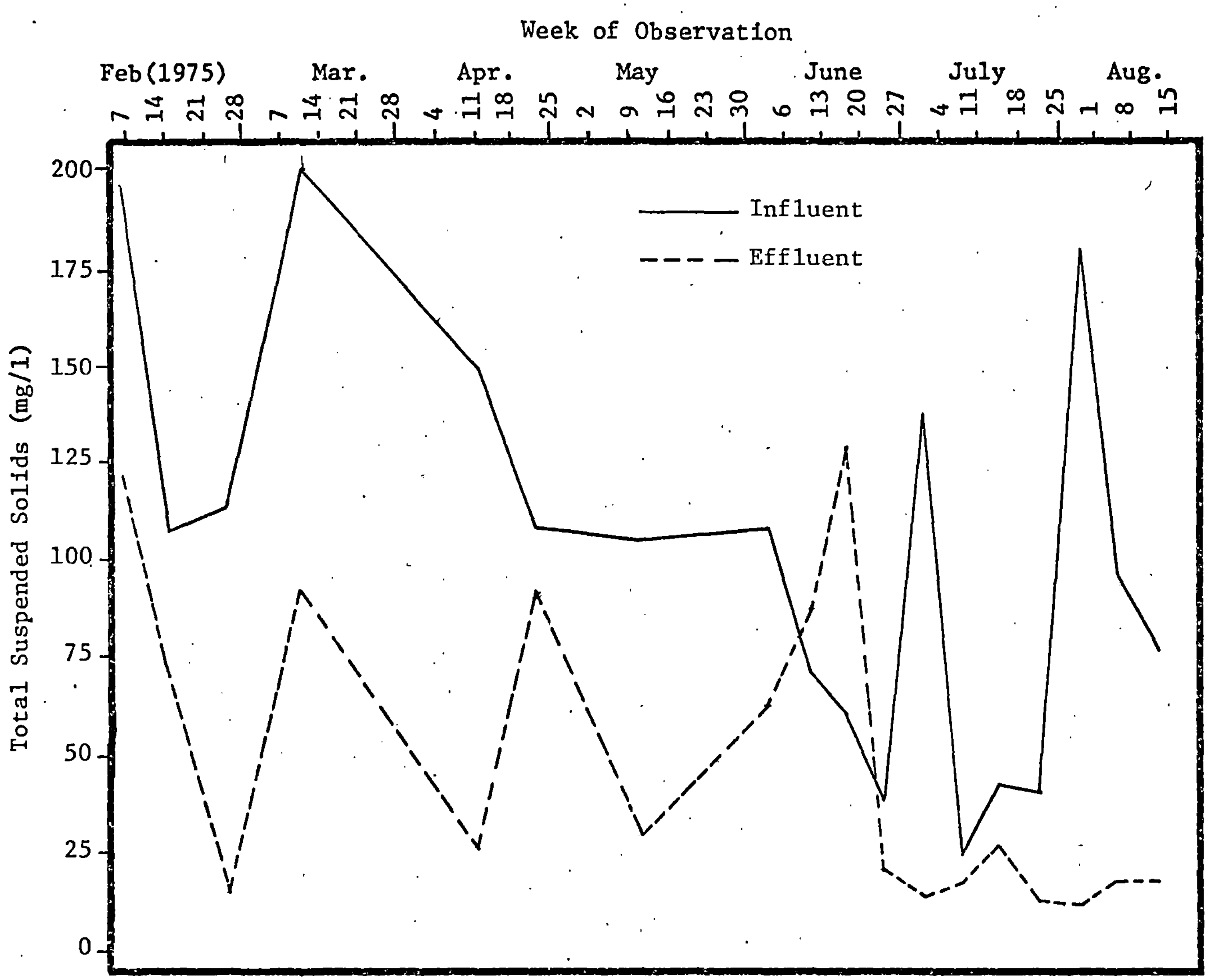

Figure 22. Total Suspended Solids (February 1975 to August 1975).

Figures 23 and 24 indicate that the volatile suspended solids are being removed between the center opening and standpipes. This removal is probably a result of biological activity in the soil within the ET unit. The biological activity reduces the solids to gases and water.

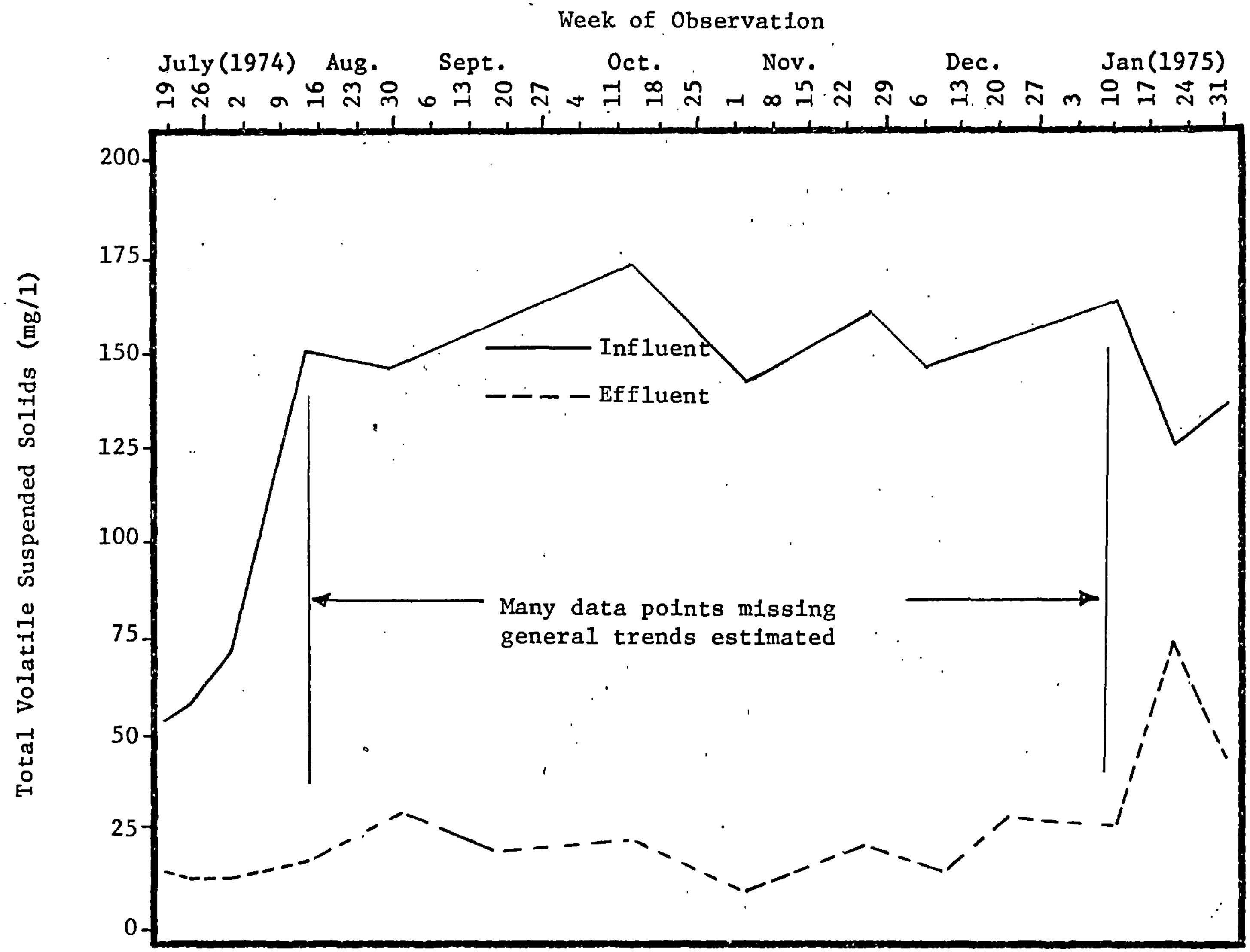

Figure 23. Total Volatile Suspended Solids (July 1974 through January 1975).

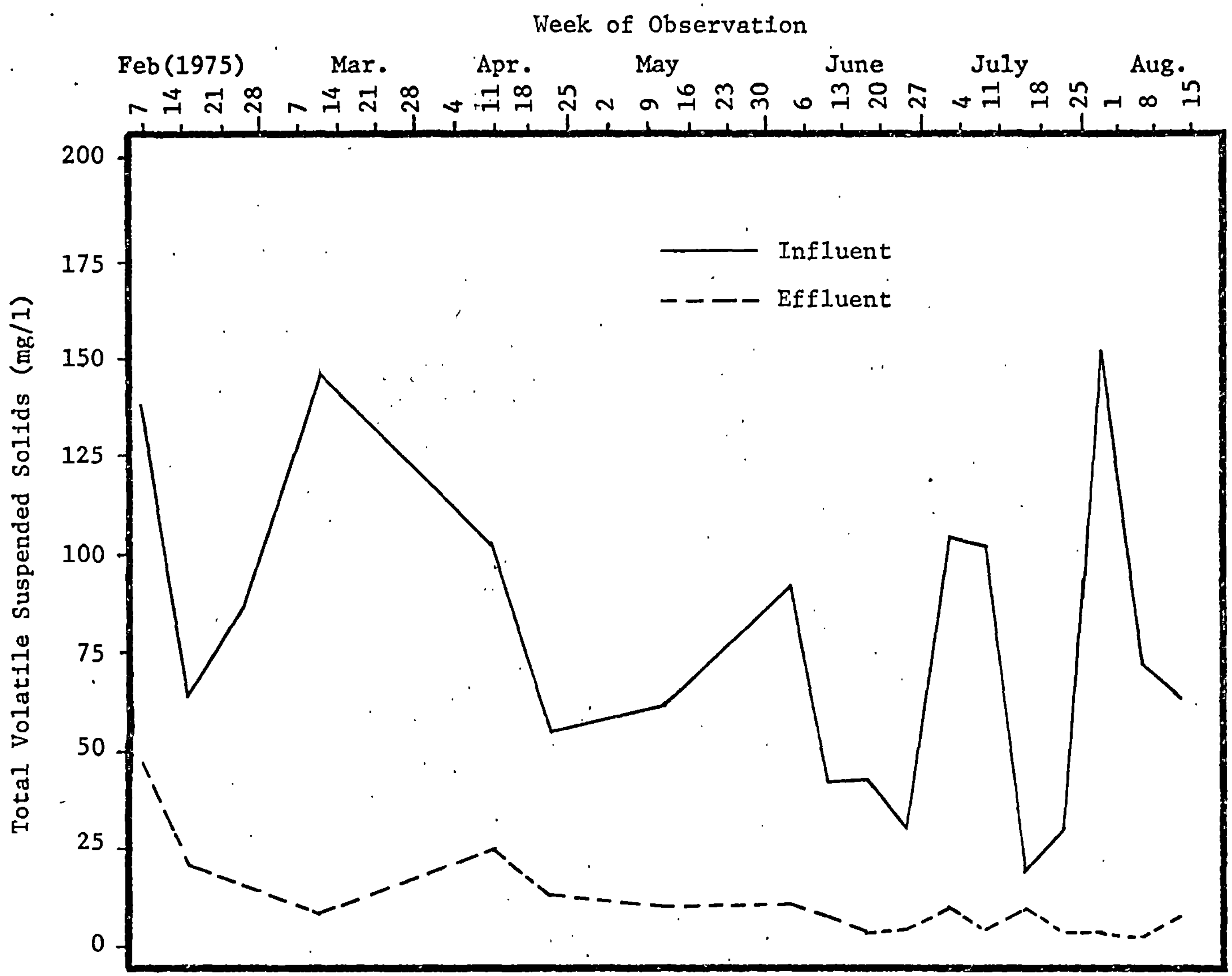

Figure 24. Total Volatile Suspended Solids (February 1975 to August 1975).

DISCUSSION AND CONCLUSIONS

Operating Conditions

The ET unit was operated over an entire year. The liquid elevation measurements and loading rates, Figures 6 and 7, along with other pertinent data cited, give conclusions which can be made concerning the loading rate of the unit to avoid overtopping the unit during the year. During the summer months (June through August), a unit of the size operated (1200 sq. ft.) in this study would support 1000 to 1500 gallons of influent wastewater per week. The fall, winter and spring seasons vary greatly from the summertime loading. With the first hard freeze during the fall, the evapotranspiration drops such that the loading rate drops to between 150 and 500 (approximation) gallons of influent wastewater per week. The later in the fall season the unit is operated, the lower the loading rate should be, until 150 gallons per week is being used as a maximum, from the middle of November or until the entire unit freezes over. When the entire unit is frozen over, the amount of influent wastewater which may be added is questionable. The value is most likely somewhere between 0 and 100 gallons per week. During some of this period zero inflow would probably be a safe situation to operate under (January and February). Perhaps in the months of March through April the amount of influent wastewater could probably be increased slowly and then as the grass starts to green in the spring on the unit, the amount of influent to the unit could be increased until in the middle of May as much as 500 gallons could again be treated by the unit.

A possibility for increasing the amount of influent wastewater into the unit during the winter and spring periods would be to cover the center opening completely with sand, gravel and soil and mound the unit slightly in the center so that precipitation and snow melt would at least partially run off of the unit instead of putting an extra load on the unit. Also wind affects would increase slightly increasing evaporation and sublimation. A covering on the center opening does not seem feasible because of only a slight benefit and the high costs involved in constructing such a cover.

The influent wastewater line for the unit should be run into the unit at least three to four feet below ground surface to avoid any possibility of freezing the line. Also, the lowest elevation of the pipe in the second home dwelling should be at least one foot above the top of the ET unit for protection against backflow from the line into the house during the winter period when the water may be under slight pressure.

Wastewater Treatment

Since there is no effluent discharged from the unit other than into the atmosphere, the unit will meet the most rigorous requirement of PL92-500 which implies a zero discharge for waste by 1985.

The actual treatment of the waste material by the unit will not meet federal standards for discharge into a stream at the present time, but the treatment is effective and occurs all during the year. The treatment of the influent wastewater during the fall, winter and spring months is essentially as effective as during the summer months (Figures 9 and 10). The coliforms indicate a decrease during the winter time and the removal rate is consistently above 90 percent. The unit also indicates a consistent

removal of suspended solids between the center opening and the standpipes whether summer or winter (Figures 21 and 22).

The dissolved solids are increasing slightly over a year's span. It is difficult to evaluate a definite amount, however. The belief is that the unit will last a number of years before the plants on the surface will reach their salt tolerance levels. The potential for damage to plants does exist, however, and the unit might require backflushing at some future date by low salinity water to lower the salt content in the unit to acceptable levels. The effect of high salt concentration may also influence bacteria population.

Esthetic Considerations

It is believed that most people would find the ET unit esthetically pleasing. Odors are no noticeable nuisance and the green color of the water at times is not truly unpleasant. An insect problem, especially mosquitos, could develop as a result of the vegetative cover and center opening.

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